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The Amount of Bone Trabeculae Supporting Subchondral Plate of Talar Body and Femoral Head

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Abstract

Background: **It is believed that the density of subchondral bone including the subchondral plate and the amount of subchondral trabeculae influences the stability of the articular surface. The collapse of the articular surface in avascular osteonecrosis is initiated by the fracture of subchondral plate and subchondral bone trabeculae. The collapse of the femoral head is found more often than that of the talar dome. A previous study showed that the talar body has a higher compressive strength than that of the femoral head. However, besides the thickness of the subchondral plate, the amount of subchondral bone trabeculae may account for the higher prevalence of the collapse of the avascular osteonecrosis of the femoral head than that of the talar body.**

Objective: **To compare the amount of bone trabeculae which supports the subchondral plate of the femoral head with that of the talar body.**

Design: **Experimental study**

Material and Methods: **Femoral heads and bodies of tali were harvested from 14 cadavers. Weight-bearing areas of the specimens were randomly selected and studied histologically by the technique of decalcified eosin-hematoxylin. The amount of bone trabeculae supporting the subchondral plate were counted by using a micrometer under light microscope.**

Results: **The amount of bone trabeculae supporting subchondral plate of the right tali ranged from 5 to 8 columns per 250 micron (mode = 7) and of the left tali ranged from 5 to 8 columns per 250 micron (mode 6). The corresponding figures of the right and left femoral head were 4 to 7 columns per 250 micron (mode = 5) and 3 to 5 columns per 250 micron (mode = 4) respectively. Statistical analysis showed that the amount of bone trabeculae supporting the subchondral plate of talus is significantly more than that of the femoral head.**

Conclusion: **The amount of bone trabeculae supporting the subchondral plate of talus was more than that of the femoral head.**

Relevance: **The results of this study suggest that one of the reasons why the prevalence of the collapse of avascular necrosis of the femoral head is higher than that of the talar body.**

Avascular necrosis of the femoral head and the talar body is a devastating disease that affects young patients. The natural progression begins with subchondral bone fracture that leads to the collapse of articular surface and subchondral cancellous bone and painful disabling arthrosis.[1] Results in the literatures provide evidence that subchondral plate plays an important role in the development of osteonecrosis.[2,3] Subchondral bone fracture is the most prognostically important variable indicating the progression toward collapse and osteoarthritis. The subchondral plate thickness also influences the stability of articular surface.[4] The greatest subchondral bone thickness is found in the region that receives maximal reaction force during normal gait cycle.[5-7] Most studies reported a high prevalance of collapse in osteonecrosis of the femoral head, and it was shown that all femoral heads progress more than 50 per cent of any Ficat stage,[8] while the collapse rate in osteonecrosis of talus was reported in only one-third of the patients.[9] One previous study showed that the talar body had a higher compressive strength at the middle of weight bearing surface than the femoral head.[10] However, the difference in the amount of bone trabeculae supporting subchondral plate may account for the difference in the prevalence of collapse of the femoral head and that of the talar body. The purpose of this study was to compare the amount of bone trabeculae which supports subchondral plate of the femoral head with that of the talar body.

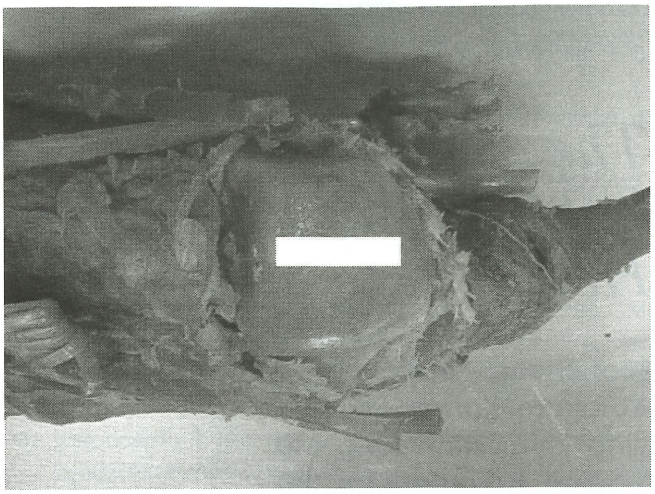

Fig. 1 Photograph of specimen showing central groove of talar dome.

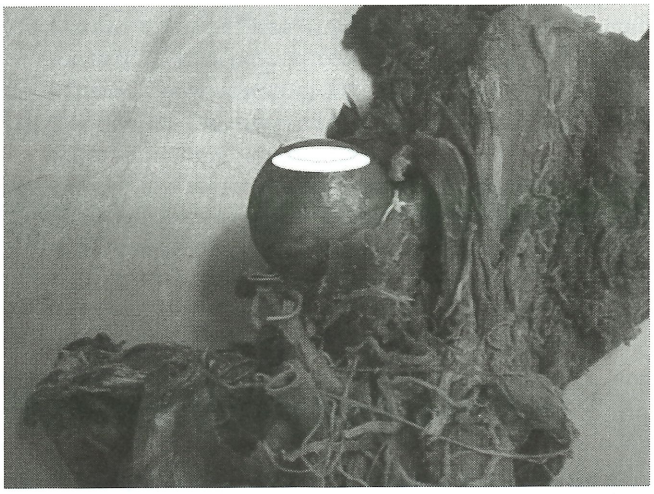

Fig. 2 Photograph of specimen showing superior quadrant of the femoral head.

Materials and Methods

Both the femoral heads and tali were harvested from 14 formalinized cadavers. The cadavers were from 9 males and 5 females with age ranging from 30 to 50 years old. Weight-bearing areas of the femoral head and the talar body were selected for histological study by the technique of decalcified eosin and hematoxylin staining. The selected weight-bearing area of the talar body was along the central groove of the anterior half (Figure 1), while the weight-bearing area of the femoral head was the superior quadrant (Figure 2). Three different areas of weight-bearing surface were randomly selected for histological study. Specimens were fixed by 10% formalin, decalcified and stained with hematoxylin-eosin. The amount of bone trabeculae supporting subchondral plate per 250 micron were counted by using a micrometer (Figure 3) under a light microscope at 10-time magnification. Counting at three different areas of each specimen were made. Data were collected and statistically analyzed with student's two-sample t-test.

Results

The amount of bone trabeculae supporting subchondral plate per 250 micron of the right and left tali ranged from 5 to 8 (mode = 7) and 5 to 8 (mode = 6) respectively. The corresponding figures for the right and left femoral heads were 4 to 7 (mode = 5) and 3 to 5 (mode = 4) respectively (Table 1, Figure4).

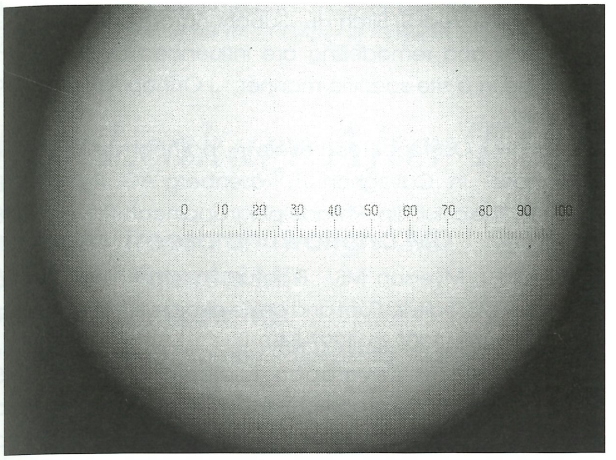

Fig. 3 A micrometer (micron) under light microscope

Table 1 The amount of bone trabeculae (columns/250 micron) supporting subchondral plate.

Specimens	N	Min.	Max.	Mode
Right tali	14	5	8	7
Left tali	14	5	8	6
Right femoral head	14	4	7	5
Left femoral head	14	3	5	4

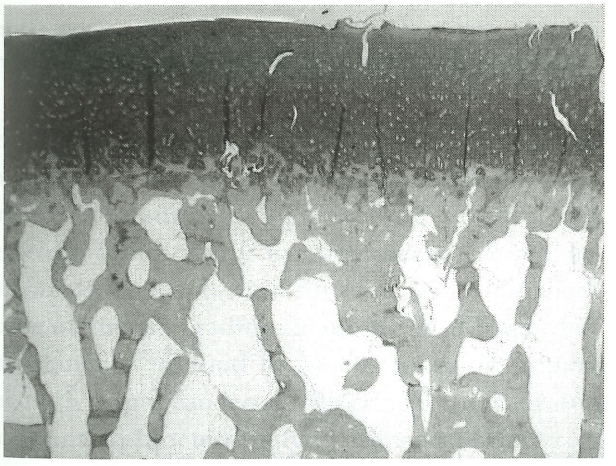

Fig. 4 Histology of subchondral plate and bone trabeculae support the plate (magnification × 10)

Statistical analysis showed that the amount of bone trabeculae supporting subchondral plate of the talus was significantly more than that of the femoral head ($p = 0.001$). However, there was no significant difference of the amount of bone trabeculae supporting subchondral plate between the right and left tali and between the right and left femoral heads ($p > 0.05$).

Discussion

The natural progression of avascular osteonecrosis leads to the collapse and painful disabling arthrosis. The process of collapse in osteonecrosis is initiated by revascularization and destruction of subchondral plate. It has been suggested that the subchondral plate influences the stability of the articular surface. Lecouvet studied the MR imaging features to differentiate between the early irreversible osteonecrosis and the transient lesions in nontraumatic lesions of the femoral condyle and found that a characteristic of the MR images which was indicative of an early irreversible osteonecrosis leading to collapse was a subchondral area of low signal intensity on T2-weighted images with thickness of more than 4 mm.[11] According to Simkin, P.A., who studied canines, subchondral bone thickness was proportional to stiffness.[12] Nakai et al, investigated the pathology of femoral head collapse following transtrochanteric anterior rotational osteotomy and found that the subchondral plate thickness and the number of trabeculae bone decreased resulting in a coarse lamellar structure of the trabeculae bone.[13] So, the thickness of subchondral plate and bone trabeculae supporting subchondral plate is an important factor in the collapse of osteonecrosis.

Phimolsarnti and Harnroongroj's study showed that the compressive strength at the middle of weight bearing area of the femoral head is lower than that of the talar body. This may be one reason of the higher prevalence of collapse of osteonecrotic of the femoral head than that of the talar body.[10] From our results, it was found that the amount of bone tarbeculae supporting the subchondral plate of the talar body was more than that of the femoral head. This may be another reason why the collapse of the femoral head was found more often than that of the talar body. The limitation of our study is that it only compared two weight-bearing joints and that there are other factors which influence the development of collapse, such as the necrotic extent and etiology. Several studies have demonstrated that the size of the necrotic lesion is important in determining whether a subchondral fracture will occur or not.[14,15]

We conclude that the amount of bone trabeculae

supporting the subchondral plate of the talar body is more than that of the femoral head and this may be one of several reasons explaining why the prevalence of the collapse of the osteonecrosis of the femoral head is higher than that of the talar body.

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